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Indian Standard

GUIDE FOR DETERMINATION OF THERMAL ENDURANCE PROPERTIES OF ELECTRICAL INSULATING MATERIALS

PART II LIST OF MATERIALS AND AVAILABLE TESTS

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GUIDE FOR DETERMINATION OF THERMAL ENDURANCE PROPERTIES OF ELECTRICAL INSULATING MATERIALS

PART II LIST OF MATERIALS AND AVAILABLE TESTS

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Indian Standard

GUIDE FOR DETERMINATION OF THERMAL ENDURANCE PROPERTIES OF ELECTRICAL INSULATING MATERIALS

PART II LIST OF MATERIALS AND AVAILABLE TESTS

0. FOREWORD

0.1 This Indian Standard (Part II) was adopted by the Indian Standards Institution on 31 January 1983, after the draft finalized by the Solid Electrical Insulating Materials Sectional Committee had been approved by the Electrotechnical Division Council.

0.2 This standard has been prepared as a guide to engineers and scientists to help in the development of test procedures to evaluate the thermal endurance of various insulating materials and simple combinations of these materials. The results of accelerated thermal tests, conducted according to prescribed procedures, may be used to establish thermal endurance profiles (TEP) and temperature indices (TI).

0.3 Thermal endurance test procedures are intended to determine the changes in properties of materials caused by long term exposure to elevated temperature.

0.4 To perform satisfactorily, insulating materials shall have the required combination of mechanical, chemical and electrical properties, evaluated separately by appropriate methods, and retain these at an adequate level throughout the service life of the equipment.

0.5 This standard is being prepared in following parts:

IS : 8504 Guide for determination of thermal endurance properties of electrical insulating materials:

- Part I-1977 Temperature indices and thermal endurance profiles;
- Part II-1983 List of materials and available tests;
- Part III- Statistical methods for determination of thermal endurance profile (*under preparation*);
- Part IV- Calculation of thermal endurance profile (*under preparation*); and
- Part V- Examples of thermal endurance test methods for specifications (*under preparation*).

0.6 This Standard (Part II) gives a list of test methods suitable for the determination of thermal endurance properties, thermal endurance profiles and temperature indices of electrical insulating materials and simple combinations thereof in accordance with IS : 8504 (Part 1)-1977*.

0.6.1 Standard tests methods to evaluate several properties of a given material or type of material permit comparison of the ageing properties of materials of different origin and of similar materials of the same type and allow the user to select the most promising materials which may be suitable for further evaluation in an insulation system.

0.6.2 For a specific material, several thermal endurance profiles and temperature indices may be specified according to the property considered and the end point chosen.

0.6.3 Standards and design engineers should find this standard useful in selecting insulating materials for various applications such as transformers, generators, motors, switchgears, and similar items.

0.7 In the preparation of this standard, assistance has been derived from IEC Pub 216-2 (1974) Guide for the determination of thermal endurance properties of electrical insulating materials : Part 2 List of materials and available tests, issued by the International Electrotechnical Commission.

1. SCOPE

1.1 This standard (Part II) gives a list of test methods suitable for the determination of thermal endurance properties, thermal endurance profiles, and temperature indices of various electrical insulating materials and simple combinations thereof in accordance with IS : 8504 (Part I)-1977*.

2. OBJECT

2.1 For a specific material, several thermal endurance profiles and temperature indices may be specified according to the property considered and the end point chosen.

It is therefore, important that standard tests of several properties of a given material or type of material are available. This permits comparison of the ageing properties of materials of different origin and of similar materials of the same type. It allows the user to select the most promising materials which may be suitable for further evaluation in an insulation system.

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*Guide for determination of thermal endurance properties of electrical insulating materials: Part I Temperature indices and thermal endurance profiles.

2.2 Table 1 lists different types of materials classified according to their physical form* and indicates applicable tests from Table 2 to determine thermal endurance profiles and temperature indices of specific materials. While in some cases, the test methods have been developed especially for this purpose, in other cases, a method for evaluating the property has been selected from already accepted methods with the object of measuring changes in the property considered. The test methods have been selected from Indian Standards so far. It is published however recognized that for particular materials or for special applications, other tests may be available which give additional or better information than those listed. When other test procedures which deviated from the test procedures specified are followed, it is important that all relevant information concerning the method and the purpose of the test be given in the relevant material specification or in the test report.

2.2.1 Where an Indian Standard exists for a particular material, the requirements given in these shall be followed.

2.3 For the purpose of determining thermal endurance properties, an end-point criterion must be chosen. Table 2 lists recommended end-point criteria for each test. If any other end-point criterion is used or no end-point is specified, the actual end-point criterion must be reported.

2.3.1 The end-point criterion should always be prescribed in the relevant material specification when not given in the test method. In test reports, all data used for the determination of the end-point should be reported, so that the statistical significance of the thermal endurance profile and temperature index may be evaluated.

3. PROCEDURE FOR THE USE OF TABLE 1 AND TABLE 2

3.1 Identify the group of materials in Table 1 which includes that for which thermal endurance tests are required. Note the tests applicable to this group and then select from Table 2 that test or these tests most appropriate for the intended application of the material.

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*In accordance with the 'encyclopedia of electrical insulating materials' edited by Swiss Electrotechnical Institution, Zurich, Switzerland.

TABLE 1 LIST OF MATERIALS

(*Clauses* 2.2. 3 *and* 3.1)

TYPE OF MATERIAL	AVAILABLE TEST	DETAILS OF RELEVANT ITEMS OF TABLE 2	
Solid insulation of all forms not undergoing a transformation during its application			
Insulation without definite form			
Formable soft masses powders, flakes, fibres		*See* Note 1	
Solid filiform insulation			
Threads and twines	Tensile strength	2.1.1	
Impregnated threads and twines	Elongation	2.2.1	
Solid insulation-sheet form			
Inorganic sheet insulation (micas)		*See* Note 1	
Films and sheets	Loss of mass	3.1.1	
	Tensile strength	2.1.2	
	Elongation	2.2.2	
	Breakdown voltage	1.1.1	
Papers, cardboards and similar products	Tensile strength	2.1.3	
	Tearing strength	2.3.1	
	Bursting strength	2.4.1	
	Viscometric degree of polymerization	3.2.1	
Fabrics and similar products		*See* Note 1	
Papers and cloths, impregnated or coated	Tensile strength	2.1.2	
	Tearing strength	2.3.2	
	Breakdown voltage	1.1.1	
Laminated sheet insulation (slot insulation, etc)	Tensile strength	2.1.3	
	Tearing strength	2.3.1	*See* Note 2
	Breakdown voltage	1.1.1	
Solid insulation non-laminated bodies			
Inorganic insulation (ceramics, glasses, quartz, and similar materials)		*See* Note 1	
Thermosetting moulded insulation	Loss of mass	3.1.2	
	Flexural strength	2.5.1	
	Breakdown voltage	1.1.2	

(*Continued*)

TABLE 1 LIST OF MATERIALS — *Contd*

TYPE OF MATERIAL	AVAILABLE TEST	DETAILS OF RELEVANT ITEMS OF TABLE 2
Thermoplastic moulded insulation	Breakdown voltage Tensile strength Flexural strength Impact resistance Tensile impact energy	1.1.2 *See* Note 3 2.1.1 *See* Note 4 2.5.1 *See* Note 5 2.9.1 *See* Note 5 2.9.2 *See* Note 4
Elastomer (vulcanized rubber and similar materials)	Tensile strength Elongation Hardness Breakdown voltage	2.1.4 2.2.3 2.6.1 1.1.3
Other non-laminated insulating materials		*See* Note 1
Solid insulation laminated bodies		
Laminates	Loss of mass Flexural strength Breakdown voltage	3.1.2 2.5.1 1.1.4
Solid sheet insulation for winding or stacking obtained by bonding superimposed layers		
Solid sheet insulation to be bonded by a pressure sensitive adhesive at normal or commonly used application temperature conditions		
Adhesive coated films	Loss of mass	3.1.4
Adhesive coated papers and fabrics	Shear adhesion to backing	2.7.1
Adhesive coated laminates	Breakdown voltage	1.1.5
Solid insulation bonded with heat		
Films bonded with heat		*See* Note 1
Papers and fabrics bonded with heat		do
Laminated sheets bonded with heat (principally mica products)		do
Solid sheet insulation bonded with heat, the adhesive containing a solvent		
Sheet laminates containing solvents (principally mica products)		*See* Note 1

(*Continued*)

TABLE 1 LIST OF MATERIALS — *Contd*

Type of Material	Available Test	Details of Relevant Items of Table 2
Solid sheet insulation bonded by simple fusion		
Films and sheets bonded by simple fusion	Loss of mass	3.1.5
	Shear adhesion to backing	2.7.1
	Breakdown voltage	1.1.1
Sheet insulation bonded by fusion and chemical reaction		
Films and sheets bonded by fusion and chemical reaction	—	*See* Note 1
Insulation which is solid in the final state but applied in the form of a liquid or paste, for filling, varnishing, coating or bonding		
Insulation solidified by physical transformation (congealing, evaporation of a solvent or gelation)		
Fusible insulating materials, without filler, liquefiable by heating	—	*See* Note 1
Fusible insulating materials, with filler, liquefiable by heating	—	*See* Note 1
Non-pigmented insulating varnishes dried by evaporation of a solvent	Loss of mass	3.1.6
	Bond strength	2.8.1 or 2.8.2
Pigmented insulating varnishes dried by evaporation of a solvent	Electric strength	1.2.1 or 1.2.2
Plastisols and organosols	—	*See* Note 1
Adhesives and mastics dried by evaporation of a solvent	—	*See* Note 1
Insulation solidified by chemical reaction (polymerization, polycondensation or polyaddition)		
	Coating resins	
Thermosetting resins, non-pigmented without solvent	Loss of mass	3.1.6
	Bond strength	2.8.1 or 2.8.2
Thermosetting resins, pigmented without solvent	Electric strength	1.2.1 or 1.2.2
	Casting resins	
	Loss of mass	3.1.2
	Flexural strength	2.5.1
	Breakdown voltage	1.1.2

(Continued)

TABLE 1 LIST OF MATERIALS — *Contd*

TYPE OF MATERIAL	AVAILABLE TEST	DETAILS OF RELEVANT ITEMS OF TABLE 2
Paste materials, hardenable, without solvent (mastics and cements)		*See* Note 1
Insulation which is solid in the final state but applied in the form of a liquid or paste, for filling, varnishing, coating or bonding		
Insulation solidified by physical and chemical change (evaporation of a solvent, followed by oxidation, polymerization, polycondensation or polyaddition)		
Non-pigmented insulating varnishes dried by solvent evaporation and chemical processes	Loss of mass Bond strength	3.1.6 2.8.1 or 2.8.2
Pigmented insulating varnishes dried by solvent evaporation and chemical processes	Electric strength	1.2.1 or 1.2.2
Insulating varnishes for the coating of electrical conductors	Electric strength	1.2.3
Adhesives and mastics dried by evaporation of a solvent and chemical processes		*See* Note 1

NOTE 1 — These groups of materials are not considered in the first stage of work.

NOTE 2 — Failure means complete rupture of the composite sheet.

NOTE 3 — Where an important reduction of specimen thickness is observed for example by thermoplastic flowing, the test is not applicable.

NOTE 4 — This test is not recommended for reinforced materials.

NOTE 5 — This test is recommended for reinforced materials.

TABLE 2 AVAILABLE TESTS

(*Clauses* 2.2, 2.3, 3, 3.1 and *Table* 1)

TEST IDENTIFICATION	TEST	TEST METHOD	SPECIMEN (*see* NOTES 1 AND 2)	END POINT CRITERION (*see* NOTE 3)
1.1	Breakdown voltage	IS : 2584-1963*		
1.1.1		5.1.3 and 7.1 of IS : 2584-1963*	150 mm × 150 mm minimum	50 percent
1.1.2		do	5.1.7 of IS : 2584-1963*	50 percent
1.1.3		5.1.1 and 7.1 of IS : 2584-1963*	do	50 percent
1.1.4		5.1.3 and 7.1 of IS : 2584-1963*	150 mm × 150 mm (only for thickness less than 3 mm)	50 percent
1.1.5		7.1.2 of IS : 7809 (Part II)-1974†	200 mm rods wrapped with tape	1·0 kV up to 2·5 kV
1.2	Electric strength	Indian standard test procedure for thermal endurance of insulating varnishes — electric strength method (*under preparation*)		
1.2.1		— alternative I curved electrode	Varnished glass fabric	118 kV/cm
1.2.2		— alternative II flat electrode	Varnished glass fabric	50 percent
1.2.3		IS : 5825-1970‡	Twisted pairs	Proof test or percentage of the electric strength
2.1	Tensile strength			
2.1.1		9 of IS : 867-1963§	Relevant to the material	50 percent maximum tensile stress
2.1.2		IS : 1969-1968‖	15 mm × 200 mm	50 percent

2.1.3		6 of IS : 9335 (Part II)-1981¶	15 mm × 180 mm	50 percent
2.1.4		IS : 3400 (Part I)-1965**	Type 1 as per IS : 3400 (Part I)-1965**	50 percent
2.2	Elongation			
2.2.1		Indian Standard relevant to the material	—	50 percent
2.2.2		IS : 1969-1968‖	15 mm × 200 mm	20 percent residual elongation
2.2.3		IS : 3400 (Part I)-1965**	Type 1 as per IS : 3400 (Part I)-1965**	*see* Note 4
2.3	Tearing strength			
2.3.1		7 of IS : 9335 (Part II)-1981¶	100 mm × 65 mm	50 percent
2.3.2		4.6 of IS : 3352-1965††	100 mm × 65 mm	50 percent
2.4	Bursting strength		100 mm × 65 mm	
2.4.1		9 of IS : 9335 (Part II)-1981¶	> 70 mm diameter	50 percent
2.5	Flexural strength			
2.5.1		11 of IS : 867-1963§	80 mm × 10 mm × 4 mm	50 percent
2.6	Hardness			
2.6.1		IS : 3400 (Part II)-1965‡‡	IS : 3400 (Part II)-1965‡‡	*see* Note 4

*Method of test for electric strength of solid insulating materials at power frequencies.

†Specification for pressure sensitive adhesive tapes for electrical purposes: Part II Methods of test.

‡Guide for evaluation of thermal endurance of enamelled wires.

§Methods of test for phenolic moulding materials.

‖Method for determination of breaking load and elongation at break of woven textile fabrics (*first revision*).

¶Specification for cellulosic papers for electrical purposes: Part II Methods of test.

**Methods of test for vulcanized rubbers: Part I Tensile stress-strain properties.

††Specification for varnished cotton cloth and tape for electrical purposes.

‡‡Methods of test for vulcanized rubbers: Part II Hardness (*first revision*)

(*Continued*)

TABLE 2 AVAILABLE TESTS — *Contd*

TEST IDENTIFICATION	TEST	TEST METHOD	SPECIMEN (*see* NOTES 1 AND 2)	END POINT CRITERION (*see* NOTE 3)
2.7	Shear adhesion to backing			
2.7.1		11 of IS : 7809 (Part II)-1977*	11.2 of IS : 7809 (Part II)-1977*	*see* Note 4
2.8	Bond strength			
2.8.1	-by the helical coil	Indian Standard method of evaluation of the thermal endurance of electrical insulating varnishes by the helical coil bond test (*under preparation*)		*see* Note 4
2.8.2	-by the wire bundle	Indian Standard method of test for evaluation of bond strength of electrical impregnating varnishes by the wire bundle test method (*under preparation*)		*see* Note 4
2.9	Impact properties			
2.9.1	Determination of charpy impact resistance	Appendix C of IS : 10192-1982†	6 × 4 × 50 mm	50 percent
2.9.2	Tensile impact energy to break plastic and insulating material	Indian Standard method of determination of the impact energy to break plastics and insulating material (*under preparation*)	To be determined	50 percent
3.1	Lose of mass (*see* Note 5)			
3.1.1		7.2 of IS : 7809 (Part II)-1977*	100 mm × 100 mm	5 percent decrease

3.1.2		do	50 mm × 50 mm × 3 mm	10 percent decrease (*see* Note 6)
3.1.3		do	50 mm × 50 mm × 3 mm	5 percent decrease
3.1.4		do	100 mm tape strips	10 percent to 20 percent
3.1.5		do	100 mm × 100 mm	10 percent decrease
3.1.6		do	Varnish 0·05 ± 0·01 mm on glass fabric base 100 mm × 100 mm (*see* Note 7)	25 percent decrease relative to varnish mass
3.2	Viscometric degree of polymerization			
3.2.1		Indian Standard method of measurement of the average viscometric degree of polymerization of new and aged electrical papers (*under preparation*)	About 2 g	25 percent

Note 1 — In every case where no thickness of the test specimen is specified, the thickness must be reported.

Note 2 — Unless otherwise specified, the initial value of the property is determined on at least 10 specimens exposed to the lowest ageing temperature for 48 h [*see* 5 of IS : 8504 (Part I)-1977‡].

Note 3 — Where there is no additional remark, the values given in percent represent the residual value of the property expressed as a percentage in relation to the initial value.

Note 4 — No generally recommendable value available.

Note 5 — In the case of loss of mass, no specification is available at the moment. Loss of mass may be useful for comparing the ageing properties of materials of similar composition and as a check on the consistency of supply of materials of allegedly the same composition, but is not suitable for establishing a temperature index or a thermal endurance profile.

Note 6 — Relative to organic material content (determined by burning out at 500°C).

Note 7 — Glass fabric as given in Indian Standard test procedure for thermal endurance of insulating varnishes — electric strength method (*under preparation*).

*Specification for pressure sensitive adhesive tapes for electrical purposes: Part II Methods of test.

†Synthetic resin bonded glass fibre (SRBGF) sheets for electrical purposes.

‡Guide for determination of thermal endurance properties of electrical insulating meterials: Part I Temperature indices and thermal endurance profiles.

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

Quantity	*Unit*	*Symbol*
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

Quantity	*Unit*	*Symbol*
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

Quantity	*Unit*	*Symbol*	*Definition*
Force	newton	N	1 N = 1 kg. m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2